

ECLAIRs: A microsatellite for the prompt optical and X-ray emission of Gamma-Ray Bursts

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ABSTRACT

The prompt γ -ray emission of Gamma-Ray Bursts (GRBs) is currently interpreted in terms of radiation from electrons accelerated in internal shocks in a relativistic fireball. On the other hand, the origin of the prompt (and early afterglow) optical and X-ray emission is still debated, mostly because very few data exist for comparison with theoretical predictions. It is however commonly agreed that this emission hides important clues on the GRB physics and can be used to constrain the fireball parameters, the acceleration and emission processes and to probe the surroundings of the GRBs. *ECLAIRs* is a microsatellite devoted to the observation of the prompt optical and X-ray emission of GRBs. For about 150 GRBs yr^{-1} , *independent of their duration*, *ECLAIRs* will provide high time resolution high sensitivity spectral coverage from a few eV up to ~ 50 keV and localization to $\sim 5''$ in near real time. This capability is achieved by combining wide field optical and X-ray cameras sharing a common field of view ($\gtrsim 2.2$ steradians) with the coded-mask imaging telescopes providing the triggers and the coarse localizations of the bursts. Given the delays to start ground-based observations in response to a GRB trigger, *ECLAIRs* is unique in its ability to observe the early phases (the first ~ 20 sec) of all GRBs at optical wavelengths. Furthermore, with its mode of operation, *ECLAIRs* will enable to search for optical and X-ray precursors expected from theoretical grounds. Finally *ECLAIRs* is proposed to operate simultaneously with *GLAST* on a similar orbit. This combination will both provide unprecedented spectral coverage from a few eV up to ~ 200 GeV for ~ 100 GRBs yr^{-1} , as well as accurate localization of the *GLAST* GRBs to enable follow-up studies. *ECLAIRs* relies upon an international collaboration involving theoretical and hardware groups from Europe and the United States. In particular, it builds upon the extensive knowledge and expertise that is currently being gained with the *HETE-2* mission.

1. Introduction

GRBs occur at cosmological distances and are the most violent explosive phenomena presently observed in the Universe. For the strongest GRBs, up to $\sim 10^{54}$ erg (assuming isotropic emission) can be radiated in the γ -ray domain on a very short timescale (from milliseconds to ~ 100 seconds). In the currently favored models, GRBs are associated with the collapse of massive stars (collapsar, Woosley 1993, Paczyński 1998) or mergers of two compact stars (two neutron stars or a neutron star and a black hole, e.g., Eichler et al. 1989) (see e.g., Piran 1999, Castro-Tirado 2001 for recent reviews). Since GRBs are observable across the whole Universe, if they are indeed linked to the ultimate stages of massive star

evolution, their redshift distribution should reveal the formation rate of massive stars up to very high redshifts, thus making GRBs effective cosmological probes (see e.g., Ramirez-Ruiz, Fenimore, Trentham 2001, Lamb & Reichart 2001).

In both the collapsar and the merger models, the final product is a stellar mass black hole and a rapidly rotating torus, from which the energy can be extracted via magnetohydrodynamic processes. The energy release in a very small volume produces a relativistic fireball with a Lorentz factor of at least a few hundred (e.g., Sari & Piran 1997). When the relativistic flow decelerates in the interstellar medium (ISM), a forward and a reverse external shock are produced. The forward external shock can account for the afterglow emission observed at radio, optical and X-ray wavelengths (Djorgovski et al. 2001 for a recent review).

Whereas the physics of the afterglow is relatively well understood, the origin of the prompt emission is still debated, especially in X-rays and optical. In the relativistic fireball model, the Lorentz factor of the wind is supposed to be variable so that successive shells of plasma have large relative velocities leading to the formation of internal shocks (Rees & Mészáros 1994, Daigne & Mochkovitch 2000, Beloborodov 2000). In that model, the non-thermal γ -ray emission is associated with either synchrotron or inverse Compton emission of electrons accelerated in those shocks. In X-rays and optical, the picture is not as clear, mostly because there are not as many high quality observations available in that energy range compared to the γ -ray domain. There is however growing observational and theoretical evidence that this energy domain contains critical information on the GRB physics, the nature of the progenitors, the way the initial bulk energy is converted into electromagnetic radiation. A better understanding of the GRB physics is required to test models predicting that GRBs may be sources of ultra high-energy cosmic rays, neutrinos, gravitational waves (see Postnov 2001 for a recent review). This understanding is also required if one intends to make GRBs a reliable tool for cosmology and for the study of the Universe at very high redshifts.

We have recently proposed to the French Space Agency (CNES), a microsatellite called *ECLAIRs*, which is specifically devoted to the observation of the prompt optical and X-ray emission of GRBs. Hereafter we briefly describe the main scientific objectives of *ECLAIRs* emphasizing on the area where it will bring an outstanding contribution (section 2). We then present the science payload and mission concept (section 3). Finally we emphasize on the complementarity of *ECLAIRs* with two other missions (*GLAST* and *SWIFT*) supposed to fly simultaneously with *ECLAIRs* (section 4).

2. Scientific objectives

With *ECLAIRs* we wish to use, for the short and long duration GRBs, the prompt optical and X-ray emission to probe 1) the physics at work during the event and 2) the surrounding of the burst to get insights on their origin. In addition, thanks to its instrumental capabilities, with *ECLAIRs*, we will investigate the existence of optical and X-ray precursors expected from theoretical grounds, and whose presence would put unprecedented constraints on any GRB models.

As far as the prompt emission is concerned, as discussed above, very few data exist in optical and X-rays in contrast to the γ -ray domain. In the optical, so far only one GRB has been detected (by the ROTSE automated telescope; GRB990123, Akerlof et al. 1999), and for a few others, upper limits are available for the late part ($\geq 10 - 20$ second after the onset) of the events (e.g. Boer et al. 2001). In X-rays, the situation is slightly better, mostly thanks to the *GINGA* (e.g., Murakami et al. 1991) and *Beppe-SAX* satellites (Frontera et al. 2000).

2.1. What can be learned from the prompt optical emission?

Sari and Piran (1999) have suggested that the prompt optical emission as the one observed in GRB990123 may be associated with electrons accelerated in the reverse external shock. The strength of the optical emission depends on various parameters, but can in principle yield constraints on the wind initial Lorentz factor and the interstellar medium density (Sari and Piran, 1999, Kobayashi 2000). Alternatively, the prompt optical emission could arise from the forward shock of the blast wave when it propagates in the pre-accelerated and pair-loaded environment (Beloborodov 2001). This emission can also give constraints on the radiation process itself; i.e., synchrotron versus Inverse Compton emission; a much stronger optical flash is expected in the Inverse Compton scenario (e.g., Daigne and Mochkovitch 1998).

The reasonable question to ask is why the prompt optical emission has so far been observed from only one GRB (GRB990123, Akerlof et al. 1999). The poor location accuracy of GRB detectors (e.g., BATSE), the delays in getting the finalized positions to the ground, the limited observing efficiency of automated optical telescopes, their response time, all conspire to make sensitive (below mag ~ 14) and truly simultaneous observations of GRBs over the whole event almost impossible. For ROTSE, the shortest response time that has been achieved is ~ 10 seconds (Kehoe et al. 2001). *ECLAIRs* will not face any of these problems as the optical and X-ray cameras will operate continuously and share a common

field of view. Optical coverage will thus be granted for all types of bursts, independently of their duration, before, during and even after the event. This unique capability will also offer the opportunity to study the transition between the prompt and early afterglow phases at similar wavelengths.

Extinction by dust in the host galaxy may naturally prevent the detection of the prompt optical emission. This is the argument used to explain the lack of optical emission in some afterglows, otherwise detected in X-rays and in radio. Dust extinction is not unexpected if GRBs are associated with massive star formation. Djorgovski et al. (2001) have however found that the *maximum* fraction of optical afterglows hidden by dust is $\sim 50\%$. This is an upper limit, as some optical afterglows may have been missed for various reasons: very high redshifts, rapid decline rate, intrinsic faintness.

ECLAIRs will seek optical emission down to magnitude ~ 15 (R band, 8 sec) for all GRBs. The properties of the prompt optical emission will be correlated with the properties of the afterglow optical emission, thus providing complementary constraints on the relativistic flow parameters and the surroundings of the event.

2.2. What can be learned from the prompt X-ray emission?

Let us now consider the prompt X-ray emission. The good correlation between the temporal behaviour of the prompt X-ray and γ -ray emissions suggests that it is also produced in internal shocks. In X-rays however, there might be additional contributions from the reverse shock (Daigne & Mochkovitch 2000), the forward shock (Beloborodov 2001) or from the photosphere of the fireball (Mészáros & Rees 2000). With its excellent sensitivity, *ECLAIRs* will observe the prompt X-ray emission from ~ 0.4 to 50 keV for all GRBs, allowing detailed time-resolved X-ray spectroscopy to be performed. These studies will set constraints on the Lorentz factor of the wind, its baryon loading, the emission mechanism and the relative contribution of the various shock regions in the overall emission.

The importance of observing the prompt X-ray emission has recently been reinforced by the discoveries of X-ray spectral features in *Beppo-SAX* observations: e.g., a transient absorption edge in GRB990705 (Amati et al. 2000) and a transient emission feature in GRB990712 (Frontera et al. 2001) (spectral features are also observed in the X-ray afterglows, e.g., Piro 1999). Well before these discoveries, it was predicted that effects of photo-electric absorption and Compton scattering from the circum-burst material should lead to observable changes in the intrinsic GRB spectrum, with the introduction of absorption cutoffs and features such as K-edges and emission lines (Mészáros & Rees 1998). In principle, these features can be used to determine the density and composition of the ISM in the immediate vicinity of the

GRB, the GRB redshift and possibly the nature of the GRB progenitor. For instance, the transient absorption edge observed from GRB990705 was satisfactorily modeled with photoelectric absorption by a medium with a large iron abundance, which could have been left there by a supernova event which occurred about 10 years before the burst (Amati et al. 2000). Similarly the transient emission feature seen in GRB990712 was shown to be consistent with thermal emission of a baryon-loaded expanding fireball when it becomes optically thin (Frontera et al. 2001). The above interpretations are however made difficult by the limited statistical quality of the data. With its improved sensitivity and good time and spectral resolution, *ECLAIRs* will be able to observe the prompt emission of GRBs over the whole event and for all types of events.

2.3. What are the short bursts ? What about the X-ray precursors ?

GRBs display a bimodal distribution in durations; the border is around 2 seconds with about 25% of the GRBs with durations less than that value. This distribution seems to correlate with spectral hardness; the shortest GRBs have on average harder spectra (Dezalay et al. 1996). It seems therefore plausible that the two distributions represent two distinct, although quite similar, physical phenomena. Extremely short GRBs may be due to primordial black hole evaporation, short GRBs to merging neutron stars, and the long ones to collapsars (see e.g., Piran 1999). So far, due to observational limitations, afterglows have only been identified for the long duration GRBs and very little is known about the short GRBs. *ECLAIRs* will have the unique capability to observe both short and long duration GRBs. These observations will thus provide clues to the following questions: How does the multi-wavelength prompt emission of the short GRBs compare with those of the long GRBs? How does the prompt emission relate to the afterglow properties? What is the redshift distribution of short GRBs? Answering these questions will help in assessing whether the short duration GRBs are of different nature than the long ones.

By its mode of operation, *ECLAIRs* will also enable us to search and study X-ray and optical precursors. X-ray precursors have already been observed (Murakami et al. 1991, Frontera et al. 2000), arising between 10 and 100 seconds before the main event. Several models have been put forward to explain these X-ray precursors (or soft excesses) (e.g., Paczyński, 1998, Nakamura 2000, Mészáros & Rees 2000), all making some specific predictions which require further data to be tested. What is the spectrum of the X-ray precursor? How does it evolves with time? How do its properties relate to the properties of the main event? These are some of the questions which will be addressed by *ECLAIRs*. In addition, Paczyński (2001) recently pointed out that there are theoretical reasons to expect strong

	E-LAXT	E-SXC	E-WFOC
Band pass	~ 3 – 50 keV	0.4–15 keV	500-700 nm
Number of units	2	6	4
Mass (kg)	25	11	14
Power (W)	21	8	16
Field of view (total, sr)	2.8	2.7	2.2
Positionning accuracy	1°	5"	5"
Number of GRBs yr ⁻¹ (total)	~ 150	~ 100	?
Limiting mag. (R) (S/N=8)	14.8, 17.4 (8, 1000 sec)

Table 1: The ECLAIRs science payload consisting of three instruments: the ECLAIRs Large Area X-ray Telescope (E-LAXT), the ECLAIRs Soft X-ray Cameras (E-SXC), the ECLAIRs Wide Field Optical Cameras (E-WFOC).

optical flashes preceding GRBs (e.g., Beloborodov 2001), the detection of which would put stringent constraints on the range of parameters for GRB models.

3. The *ECLAIRs* mission concept

The *ECLAIRs* mission concept results from the scientific goals described above and is optimized under the stringent constraints of a microsatellite: 50 kilos, 50 Watts and a total volume of 60 cm × 60 cm × 30 cm (length, width, height) available for the science payload. *ECLAIRs* was presented to CNES in May 2001. The review committee strongly recommended *ECLAIRs* to be studied by the CNES microsatellite division. The technical assessment phase will start in early 2002. Therefore this means that the science payload described below is as it was stated in the proposal, and does not account for the results of the CNES study. Depending on the outcome of the final selection by CNES, the US contribution to *ECLAIRs* will be the subject of a SMEX/MOO proposal in 2002.

3.1. The science payload

The science payload consists of three sets of instruments (see Table 1). The Large Area X-ray Telescope (E-LAXT), the Soft X-ray Cameras (E-SXC), and the Wide Field Optical Cameras (E-WFOC) (see Fig 1). This payload will be provided by a consortium of institutes which have developed over the years a considerable expertise and knowledge in the preparation and operation of missions, such as *HETE-2* and *INTEGRAL*.

3.1.1. *ECLAIRs - Large Area X-ray Telescope*

The Large Area X-ray Telescope (E-LAXT) is made of two identical conventional coded-mask imaging telescopes. For each telescope, the detector is a matrix of 32×32 Silicon PIN diodes, 2mm thick, 1cm^2 each. The mask (cell size 1cm^2) is located 20 cm above the detector plane. The imaging system provides a field of view (FOV) of 1.4 steradian, an angular resolution of 4 degrees, and an accuracy of localization of ~ 1 degree. For a simplified model of the imaging system (mask and detector), we have found that at 10 keV, for a burst occurring 20° off-axis (mean value), the effective area of one module is around 350 cm^2 . The important parameter that gives the number of GRB detected is the product of the field of view (Ω) and the effective area (A). For *ECLAIRs* we have found $\langle \Omega A \rangle \sim 490 \text{ cm}^2 \text{ sr}$, and this value is about a factor 15 larger than the *Beppo-SAX* value. From $\langle \Omega A \rangle$ so computed, scaling from the *HETE-2* value ($\langle \Omega A \rangle \sim 65 \text{ cm}^2 \text{ sr}$ and a rate of 40 GRB yr^{-1} assuming an observing efficiency of 100%), it is straightforward to show that one unit of E-LAXT should detect 90 GRB yr^{-1} . When combining the two units, E-LAXT should therefore detect 150 GRB yr^{-1} . The latter estimate is fully consistent with the one expected from the BATSE rate, accounting for the difference of band-pass between E-LAXT and BATSE.

Each detector of E-LAXT is made of a matrix of modules of 8×8 of Si PIN diodes. The development of such matrices and associated low-noise low-power front-end electronics is funded through a CNES R&T program started at CESR in collaboration with the company EURISYS (Strasbourg, France). The expected noise level should result in an energy resolution of ~ 1 keV (at 6 keV, -40C) making possible a low energy threshold of ~ 3 keV. The thickness of the diodes ensures the energy coverage up to ~ 50 keV.

3.1.2. *ECLAIRs - Soft X-ray Cameras*

The Soft X-ray Cameras (E-SXC) for *ECLAIRs* are based upon the successfully-flown *HETE-2* design (Ricker 2001). The operating principle is that of a coded-mask imager, in which a 1-D coded mask is rigidly suspended above an X-ray charge-coupled device (CCDID-34). The E-SXC assembly is made of 6 camera modules, covering a field of view of 2.7 sr. The CCDID-34 (3K×6K array; $10\mu\text{m}$ square pixels, $20''$) has an overall size of 30 mm×60 mm and is currently in production at MIT Lincoln Laboratory. It improves over the CCID-20 used for *HETE-2* by a greater energy coverage (0.4-15 keV versus 0.8-10 keV), a better time resolution (0.25 sec versus 1 sec), and a better quantum efficiency (sensitivity of ~ 400 mCrab, 1 sec, 4σ). The E-SXC will provide 5" burst localizations (at S/N =8). About 100 GRBs yr^{-1} should be detected in the 6 units.

3.1.3. *ECLAIRs - Wide-Field Optical Cameras*

The Wide-Field Optical Cameras (E-WFOC) for *ECLAIRs* are derived from the star camera units successfully flown on *HETE-2* (Ricker 2001). The large field of view (2.2 sr) is achieved by four such cameras. The limiting magnitude in R is 14.8 (8 s at S/N=8) for one E-WFOC. Each of the four modules utilizes a moderately fast, well-corrected optical lens (focal length of 80 mm, f/0.9) coupled to a 2×2 array of MIT CCID-34 sensors, resulting in a hybrid focal plane with $6\text{K} \times 6\text{K}$ pixels; each pixel is $10\mu\text{m} \times 10\mu\text{m}$ ($25.8''$). The integration time is 2 seconds.

To achieve the light weight and low power required for *ECLAIRs*, the drive and read-out electronics, as well as the digital frame buffer memory, for the E-SXC and E-WFOC instruments will be combined to the maximum degree possible.

The operating mode for the E-WFOC relies upon digitizing and storing successive 300 MB image frames in a four stage deep buffer, requiring a total of 1.2 GB SRAM. In response to triggers from the E-LAXT or E-SXC, we will select $4^\circ \times 4^\circ$ regions-of-interest (ie 512 x 512 subarrays) from this large buffer, centered on the suspected burst coarse localization, for transfer into an optical burst memory. In addition, neighborhoods of twenty-five stars, extending out to 64×64 pixels ($27' \times 27'$), will also be stored as astrometric and photometric references. The accumulation of 500 frames (=1000 sec), each with burst and reference star data, will reside in 377MB of SRAM, and require 3 minutes to downlink during an X-band contact with an *ECLAIRs* ground station. Shift-and-add summation of the digitized, two-second resolution CCD data in ground processing will permit the E-WFOC to achieve an ultimate limiting sensitivity of R=17.4 (1000s at S/N=8). Centroiding will result in bright optical transient localizations accurate to $\pm 2''$, even in the presence of spacecraft pointing drift (assumed to be $47''/\text{s}$, 3σ , as specified for the Myriade spacecraft). For long term optical monitoring, we will also be able to downlink 45 full image frames per day (ie 2.2 sr at full angular resolution, every ~ 30 minutes), each containing more than 2.5 million star images. Downlinking of the full frame data will require 13 GB/day.

3.2. Implementation of the mission

The baseline for *ECLAIRs* is an equatorial orbit for a low, stable background, low radiation damage to the CCD, and for the download of the science data to be possible with a single ground station. This orbit could be achieved by various launchers, as for example a PEGASUS from the Marshall Island or from Alcantara. We plan to reuse the *HETE-2* ground segment. In particular, one of the 3 S band stations (Singapore, Kwajalein, or

Cayenne) will be converted to X band. For the alert system, we plan to use the *HETE-2* network of 12 VHF stations located along the equator. As will be discussed below, the science return of *ECLAIRs* could be significantly enhanced if it could fly simultaneously with *GLAST*; therefore the planned launch date is end of 2006 and the lifetime of the mission is foreseen for 5 years for a maximum synergy with *GLAST*.

3.3. Operational considerations

As far as the attitude control is concerned, the instruments will always point in the anti-earth direction. The triggering system of *ECLAIRs* is relatively simple. The on-board computer monitors continuously the count rates in E-LAXT. When a transient event is detected, a signal is sent to the E-SXC and E-WFOC for the most recent data to be stored in a dedicated memory. Two images from E-LAXT are then reconstructed before and during the event. From the difference of the two images, the rough position (~ 1 deg accuracy) of the event is obtained and sent out to the ground and to the secondary instruments which use this position to obtain the final more accurate position. After ~ 30 seconds, the final position (5" accuracy) is transmitted to the ground. During the next passage to the ground station a high rate X-band communication (16 Mbits/s) allows the whole data set associated with the event to be downloaded.

The operations of the spacecraft will be conducted by the CNES control center at Toulouse, whereas the science operations will be conducted at CESR. The SOC will be responsible for the health monitoring of the science payload, the quick-look analysis of the data for rapid dissemination, the data archives and the Education and Public Outreach program. The software for the data analysis will be provided by a consortium of institutes involved in the project.

4. A mission complementary to *GLAST* and *SWIFT*

*GLAST*¹ is scheduled to be launched in March 2006 into a low earth orbit. The satellite will carry 2 instruments: the Large Area Telescope (LAT), which will observe emission from 20 MeV to 200 GeV, and the Gamma-ray Burst Monitor (GBM), which will detect transients from 20 keV to 20 MeV. The LAT detector is 50 times more sensitive than its predecessor, *EGRET*. While only a few GRBs were detected by *EGRET*, *GLAST* is expected

¹<http://www-glast.stanford.edu/>

to observe nearly 200 GRBs per year. These bursts will also be detected by the GBM, so that the spectrum will be measured over 7 orders of magnitude. Unfortunately, only for the brightest bursts the positions derived by the LAT will be accurate enough to be used for follow up observations. Provided that *ECLAIRs* and *GLAST* can remain on a similar orbit (adjustment and maintenance of the orbit can be easily achieved with microthrusters) *ECLAIRs* would greatly enhance the *GLAST* science, by both extending the spectra to lower energies (down to ~ 2 eV) and by improving the localizations in near real-time to enable follow-up observations in the afterglow regime. Given that the GBM has a FOV much larger than *ECLAIRs*, all GRBs seen by *ECLAIRs* will be also detected by the GBM, thus providing for ~ 150 GRB yr $^{-1}$, spectral coverage from about 7 decades in energy, and for those detected by the LAT (~ 80) over 11 decades in energy! This broad band spectral coverage will enable discrimination between the various radiation processes proposed for the multi-wavelength GRB emission, including those, yet to be tested, put forward for the GeV emission (inverse Compton, Synchrotron emission, see e.g., Waxman 1997, Böttcher & Dermer 1998). This will open a completely new window on the GRB physics, setting for the first time real constraints on models predicting that GRBs are sources of ultra-high energy cosmic rays and neutrinos. Furthermore, the ability to locate the *GLAST*-GRBs precisely, making possible the identification of the host galaxies and the measure of the redshifts will enable the systematics of the GeV emission to be studied, and the *GLAST*-GRBs to be compared, as a class of events, to the GRBs detected by satellites operating at lower energies (*Beppo-SAX*, *HETE-2* and *SWIFT*). Finally, for those GRBs for which the redshift will be determined, cut-offs in the observed GeV spectrum can be used to infer the level of ultra-violet to infra-red background light which is a direct tracer of star and Galaxy formation in the early Universe (Salamon & Stecker 1998). The complementarity between *GLAST* and *ECLAIRs* is best illustrated in Fig. 2 where the observing energy range is plotted against the observing time window of the events. *ECLAIRs* was presented at the last *GLAST* GRB working group and received strong support.

*SWIFT*² is a NASA mission dedicated to the study of the GRB afterglows. It should be launched in Fall 2003, with a nominal on-orbit lifetime of 3 years. It will carry three instruments: The Burst Alert Telescope (BAT) covering the 15 to 150 keV range, and two Narrow Fields Instruments (NFIs); the X-Ray Telescope (XRT, 0.2-10 keV) and the UV Optical Telescope (UVOT, 170-650 nm). The observing strategy of *SWIFT* is to point the NFIs after the detection of a GRB in the BAT. This strategy clearly means that *SWIFT* will miss the early X-ray and optical emission of all GRBs. The time to point the NFIs to the direction of the GRB should range between 20 and 70 seconds, with a mean value of 50 sec.

²<http://swift.sonoma.edu/>

Its ability to observe the precursors and activity during the burst will also make *ECLAIRs* a very complementary mission to *SWIFT* (see Fig. 2).

5. Conclusions

Fortunately GRBs are extremely bright events which can easily be detected and studied with an instrumentation matching the stringent constraints of a microsatellite. GRBs have been proved to be highly complex phenomena whose understanding requires multi-wavelength observations of the prompt and afterglow phases and follow-up ground-based observations to determine their host galaxies and their redshifts. *ECLAIRs* will thus bring a significant contribution to a better understanding of GRBs by providing high sensitivity observations of the prompt optical/X-ray emission and accurate localization of about 150 events per year.

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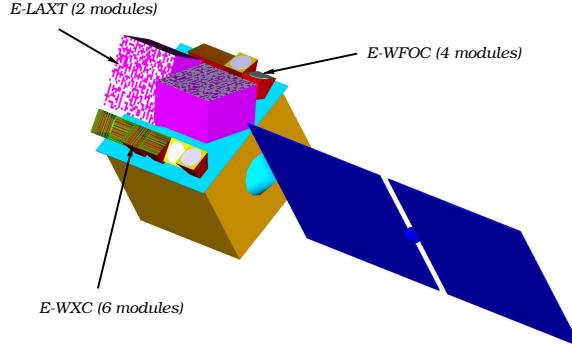


Fig. 1.— The *ECLAIRs* science payload on a microsatellite Myriade spacecraft. The three sets of instruments which are shown fit within the geometrical constraints imposed to the science payload. Detailed accommodation of the payload on the spacecraft will be studied by CNES in early 2002.

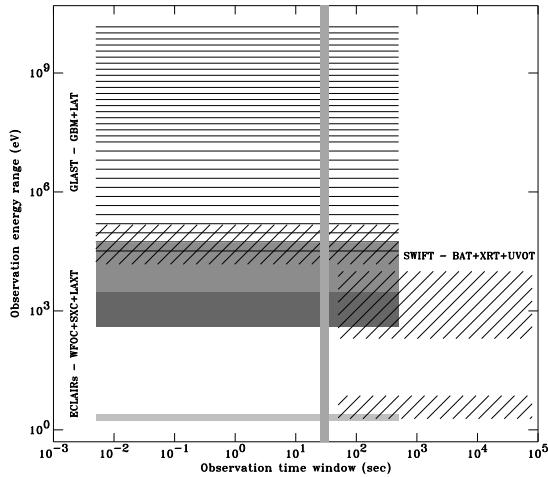


Fig. 2.— Comparing *ECLAIRs* (filled regions) with *GLAST* (horizontal lines) and *SWIFT* (tilted lines). The time window of the observations is given on the X axis whereas the Y axis represents the energy range of the instruments. As can be seen, the combination of *ECLAIRs* and *GLAST* would provide spectral coverage over 11 decades in energy. Note also the complementarity between *ECLAIRs* and *SWIFT*; *ECLAIRs* is focused on the prompt optical/X-ray emission whereas *SWIFT* is designed for the afterglow emission in the same energy range. The mean GRB duration is also shown for indication (vertical box).